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PCT / IN04 / 00070
26 MARCH 2004 (26.03.04)

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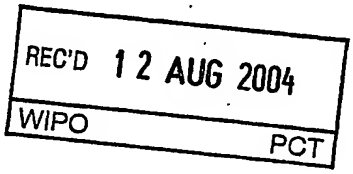
TO ALL TO WHOM THESE PRESENTS SHALL COME:

25th June, 2004.



THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY OF *PATENT APPLICATION NO. 188/KOL/03 FILED ON 28/03/2003* FROM THE RECORDS OF THE PATENT OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED INTERNATIONAL PATENT APPLICATION FILED AT RECEIVING OFFICE, INDIA THAT MET THE REQUIREMENTS TO BE GRANTED A DOCUMENT UNDER SECTION 147 OF THE PATENTS ACT, 1970.

INTERNATIONAL APPLICATION NUMBER: PCT/IN04/00070.

INTERNATIONAL FILING DATE: 26TH MARCH, 2004.

PRIORITY DOCUMENT
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By Authority of the
CONTROLLER GENERAL OF PATENTS,
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(Dr. P. C. Chakraborti)
Certifying Officer

FORM-1 (To be filed in Triplicate)

THE PATENTS ACT, 1970

(39 of 1970)

APPLICATION FOR GRANT OF A PATENT

[See Sections 5(2) 7, 54 and 135]

1. We THE TATA IRON AND STEEL COMPANY LIMITED., Research and Development and Scientific Services Jamshedpur 831 001, India, an Indian Company.

2. hereby declare—

(a) that ~~I am~~ / We are in possessin of an Invention titled

A SYSTEM FOR ON-LINE PROPERTY PREDICTION (OPPRESS) FOR HOT ROLLED COIL IN HOT STRIP MILL (HSM)

Title

(b) that the Provisional / ~~Complete~~ Specification relating to this invention filed with this application.

(c) that there is no lawful ground of objection to the grant of a patent to me / us.

3. Further declare that the inventor(s) for the said invention is / are :

Surname first and then name of inventor/s

MUKHOPADHYAY ANANYA, an Indian national,
C/o. The Tata Iron and Steel Company Limited,
Research and Development and Scientific Services,
Jamshedpur 831 001, India,

4. I/We, claim the priority from the application(s) filed in convention countries, particulars of which are as follows :

NA

5. I/We state that the said invention is an improvement in or modification of the invention the particulars of which are as follows and of which I/We are the application/patentee:

NA

6. I / We state that the application is divided out of my/our application, the particulars of which are given below and pray that this application be deemed to have been filed on.....NA.....
under section 16 of the act.

7. That I am / We are the assignee of the true and first inventors.

8. That my / our address for service in India is as follows :

L S DAVAR & CO.,
Monalisa, Flats IB & IC, 17, Camac Street,
Kolkata-700 017.
Phones : 247-3996, 247-5918, 280-5536
Fax No. : 91-33-247-5886, 240-6292
91-11-646-4443

9. Following declaration was given by the inventor(s) or applicant(s) in the convention country :
I / We the true and first inventors for this invention or the applicant(s) in the convention country declare that the applicant(s) herein is / are my / our assignee or legal representative.

Signature of the true and first Inventor/s or Applicant In the convenstion country with date, name to be given below Signature

MUKHOPADHYAY, ANANYA

10. That to the best of my / our knowledge, information and belief the fact and matters stated herein are correct and that there is no lawful ground of objection to the grant of patent to me / us on this application.

11. Following are the attachment with application :

(a) Provisional/~~Complete~~ specification (3 copies).

(b) Drawings 2 (Sheets) 3 copies.

(c) Priority document/s NA

(d) Statement and undertaking on Form 3 in dupl.

(e) Form 5. NA

(f) Power of Authority. To Follow

(g)

(h)

(i) Fee Rs. ~~1,500/-~~/Rs. 5,000/- in cheque / bank draft. bearing No.....date..... on.....Bank.

To be Signed by applicant or authorised patent agent

I/We request that a patent may be granted to me/us for the said invention.

Dated this 28th day of March 2003

Signature ( )

OF L.S. DAVAR & Co.
APPLICANTS' AGENT

To
The Controller of Patents
The Patent Office
at Kolkata

188/Kol/03

C.21D

0218827/00

FORM – 2

THE PATENTS ACT, 1970

(39 of 1970)

PROVISIONAL/COMPLETE

SPECIFICATION

SECTION 10

TITLE

A SYSTEM FOR ON-LINE PROPERTY PREDICTION(OPPRESS) FOR HOT ROLLED COIL IN HOT STRIP MILL (HSM)

APPLICANT

THE TATA IRON AND STEEL COMPANY LIMITED.,
Research and Development and Scientific Services
Jamshedpur 831 001, India, an Indian Company

The following specification particularly describes the nature of the invention and the manner in which it is to be performed

Field of Invention

The present invention relates to a system for on-line property prediction (OPPRESS) for hot rolled coil in hot strip mill (HSM). This invention is in the area encompassing automation, R&D, applied to metallurgical processes with specific reference to mechanical property of hot rolled coil.

Background of the Invention

In hot strip mill the slabs are heated and soaked at elevated temperature (~1200°C) in the reheat furnace, and are subjected to subsequent reduction in the roughing and finishing mill. All reductions are completed in the austenitic phase (~890°C) before the strip enters in the Run-Out Table (ROT). The strips are cooled down to ~600°C by using laminar water jets on the ROT, before being coiled in the down coiler.

Once the coil is produced in HSM, its mechanical property is tested to verify whether it fulfils the criterion mentioned in Technical Delivery Condition (TDC). The mechanical properties the coil is tested by performing tensile tests on INSTRON machine. The specimen used for the tensile testing is prepared from a cut-out sample of the outer wrap of the coil produced in the mill. The cut-out sample is then machined to prepare the tensile testing specimen. From the stress-strain graph generated from the tensile testing machine, the mechanical properties such as Yield Strength (YS), Ultimate Tensile Strength (UTS) and Percentage Elongation (%EL) are obtained. The test results are posted in the Test Certificate (TC) before the coil is shipped to the customer.

The drawback of the existing method is that only one sample per coil can be tested, since coil cannot be cut from the middle for taking samples. Thus the sample is not representative of the entire coil.

Another disadvantage of the existing method is that because of the very nature of cooling process, non-uniform cooling takes place from the end of the coil. Hence, the property at the end is very much different from that of the body.

Summary of the Invention

To improve the qualify and to achieve the stringent property requirements, a system has been designed, developed and implemented to monitor the property deviation over the length of HR coil as the coil is rolled. This helps the operator to take corrective actions so as to get nearly uniform mechanical properties along the length. The system stores data for every coil into the system for 3 days.

The salient features of the system of the present invention are –

- The system has been designed, developed, validated and implemented.
- It is a real time system development.
- Prediction of cooling rate, ferrite grain size, aluminium nitride particle size, amount of nitrogen in solution.
- Development of thermal, phase transformation, precipitation and structure-property correlation model on-line.
- Prediction of through thickness mechanical properties of the strip.
- Prediction of cooling temperature (valid for all grades of steel).
- Prediction of mechanical properties valid for Grade D, DD, EDD and CRM-CQ grades.

To obtain the mechanical properties of the hot rolled coil it is the usual practice to do tensile testing of the specimen, cut from the outer wrap of the HR coil, a Tensile Testing Machine. This means thaqt there is only one sample per coil that is used to represent the mechanical properties of the whole coil. Obviously, the sample from outer wrap of the coil does not represent the whole population along the length of the coil. Also, the variation of mechanical properties along the length of the coil cannot be obtained. Since, the variability of properties along the length need to be within control from the point of view of application and further processing, it is important to know this variation during rolling of HR coil in HSM so that the corrective and preventive action can be taken. From this point of view, the system for online property, prediction of HR coil has been originated. The system captures the chemistry of the HR coil from the steel making stage, and the process parameters during hot rolling. The system then calculates in real-time the mechanical properties during cold condition after coiling at various points along the length and also across the thickness. It also predicts the conditioning of aluminium nitride after coiling, which in turn gives the forming properties of CR coils after batch annealing.

The system is made for all grades of steel, although at present it is validated with low carbon grades such as Grade D, DD, EDD and CRM CQ. The accuracy of the system is ± 15 Mpa, and reliability is 85%.

Brief Description of the Accompanying Drawings

Figure 1 shows a schematic diagram for the system of the present invention.

Figure 2 shows the system output displayed on a CRT screen.

Detailed Description

The invention will now be described in detail with the help of figures of the drawings.

Figure 1 shows the schematic diagram of the system. For each coil the system receives real-time data in every second from the field devices (Level-1) such as pyrometer, speedometer, thickness gauge etc to the mill VAX computer through Programmable Logic Controllers (PLCs). The time-domain data are then converted to space domain data through segmentation. The space domain data, which involves FRT, CT, rolling speed, cooling condition for a given position on the strip, goes as input to the physical model. The PHYSICAL MODEL has five modules.

(a) Deformation Module
(b) Thermal Module
(c) Microstructural Module
(d) Precipitation Module
(e) Structure-Property Correlation Module

Deformation module determines final austenite grain size finish rolling. The final austenite grain size depends on strain (reduction per pass), strain rate (speed of deformation), and temperature of deformation, inter-pass time etc.

Thermal module determines temperature drop during radiation in air and cooling in water at ROT. It calculates the cooling rate, which determines the recrystallisation behaviour and the phase transformation.

Microstructural module determines the microstructural changes during phase transformation.

Precipitation module determines the amount of aluminium and nitrogen in solution and also as precipitates after coiling.

Structure-property correlation calculates the YS, UTS and %EL based the phases present.

The output of the system gives cooling rate, volume fraction of aluminium nitride, and the mechanical properties (YS, UTS, EL) over the length and through the thickness of the coil. These are displayed on the CRT screen for every coil at various positions of the strip as shown in Fig.2. The predicted coiling temperature is also shown via-a-vis the actual in order to ensure that the predicted cooling rate (CR) to achieve the CT as obtained from the thermal model is accurate enough. Apart from these, the average values over the length are also calculated. The properties of the tail-end of the coil (outer wrap) is also displayed since this can directly be verified from the tensile testing results of the specimen taken from the coil.

The data for each coil so generated are stored in the system and, are sent to the Data Warehouse, where they are stored for future use.

The system architecture of the on-line property prediction (OPPRESS) for hot rolled coil in hot strip mill comprises a client-server architecture where it receives data from mill VAX computer, the client. The mill VAX computer acquires data from PLCs through SCADA. The data transfer to the server is done through LAN. The server runs on Windows 2000 operating system. The predicted data are sent automatically to Data Warehouse and AS-400 through FTP as and when generated.

The system is useful for accurate prediction, and a first-order control for the mechanical property variations of the HR coil along the length, and through the thickness. Test Certificate can be generated from the system in future. Physical testing (e.g., tensile testing) can be reduced drastically. This will reduce cost of HR coil/tonne. With the knowledge of aluminium nitride in the strip annealing parameters can be set appropriately to obtain right r-bar and n-value of CR coil. Coil delivery can be made faster at customer's end.

The system is helpful in designing steel grade and process parameters. These would lead to rationalization of grades by reducing large number of grades to smaller number of grades with larger varieties of mechanical properties.

Key Words

OPPRESS	:	On-line Property Prediction System
ROT	:	Run-out Table
HSM	:	Hot Strip Mill
On-line	:	Real-time
Mechanical Properties	:	Properties related to strength
YS	:	Yield Strength
UTS	:	Ultimate Tensile Strength
EL	:	% Elongation
$\bar{r}$	:	Plastic strain ratio
n	:	Work hardening exponent

Dated this 28th day of March 2003.

B B SEN
OF L S DAVAR & CO
Agent for the applicant

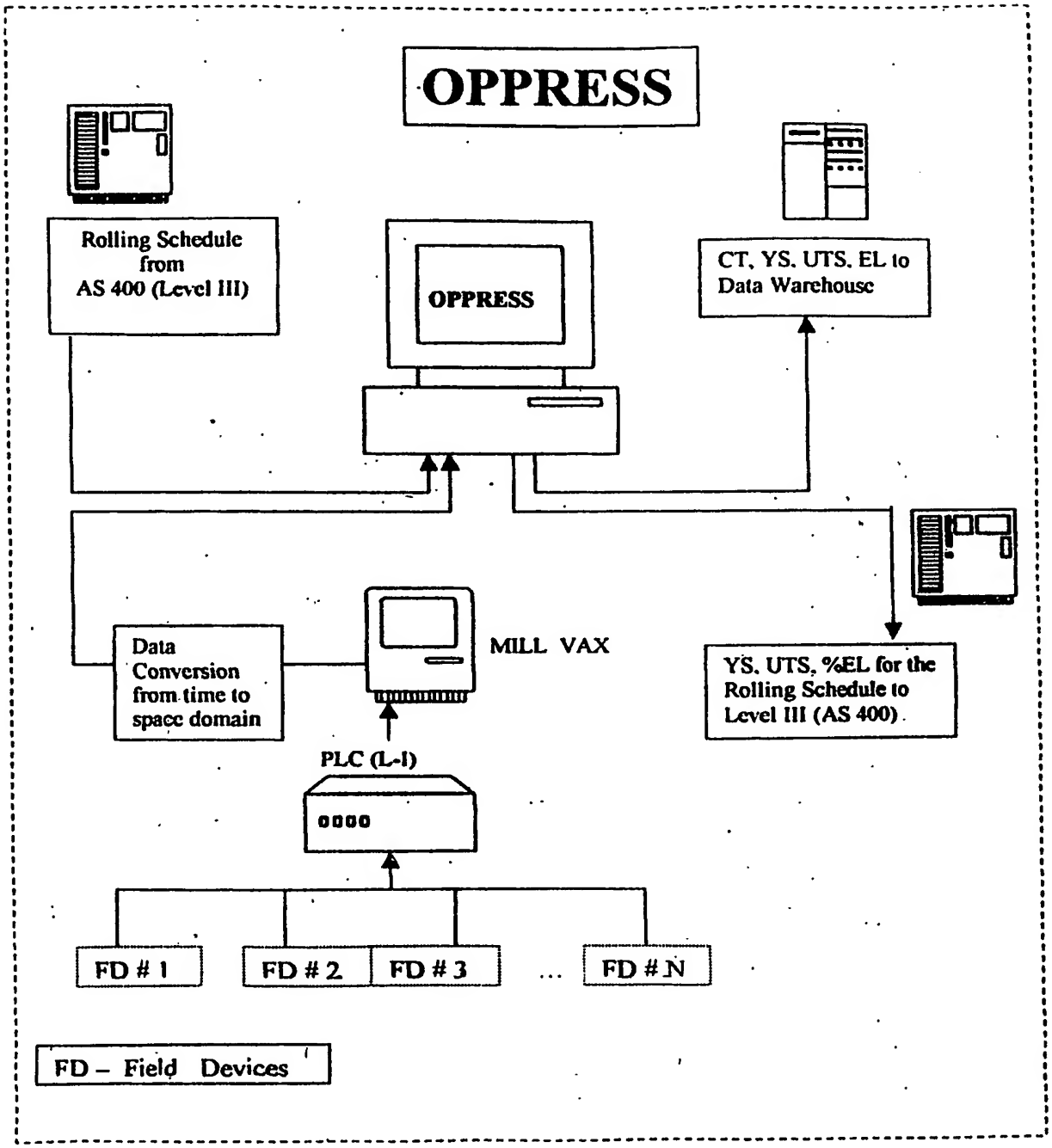

Fig. 1 : Schematic of On-line Property Prediction System (OPPRESS)

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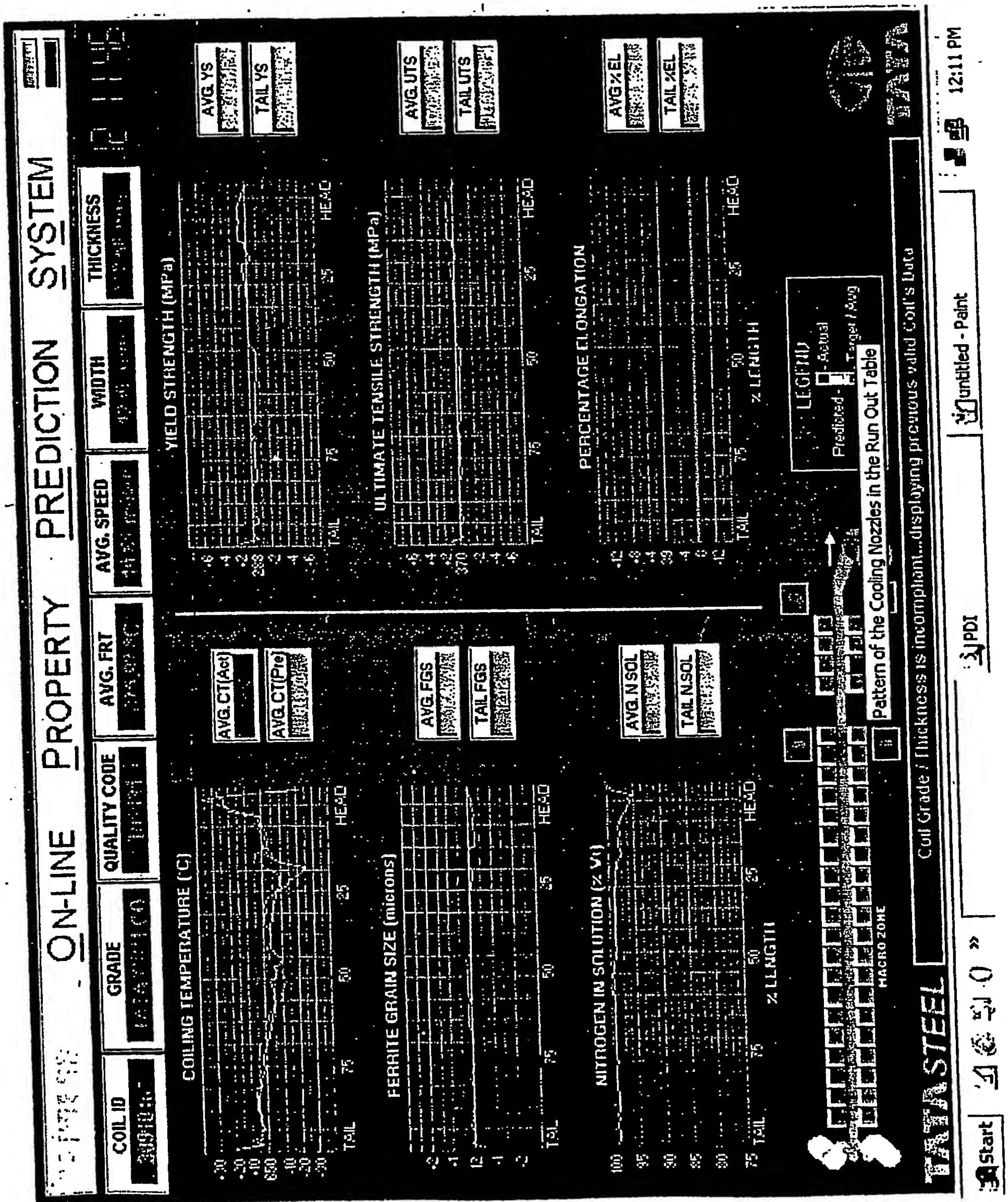
APPLICANTS' AGENT

HE TATA IRON & STEEL CO. LTD.

2 SHEETS
SHEET 2



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